AD-A214 926

(2)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE November 24, 1980

3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE
ADVANCES IN OCULOMOTOR AND VESTIBULAR PHYSIOLOGY

5. FUNDING NUMBERS
61102F
2312 A1

6. AUTHOR(S)
Bernard Cohen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
New York Academy of Science
2 East 63rd Street
New York, N.Y. 10021

8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 89-1421

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR
BLDG 410
BAFB DC 20332-6448

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFOSR-80-0277

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
The Barany Society-New York Academy of Science Conference on Advances in Oculomotor and Vestibular Physiology was held on September 22-25, 1980 at the Barbizon Plaza Hotel in New York City. 75 Speakers presented material on both basic and clinical aspects of vestibular and oculomotor system organization. The meeting was supported by the Air Force Office of Scientific Research, the National Aeronautics and Space Administration, the National Institute of Neurological and Communicative Disorders and Stroke, and the Pfizer Corporation.

14. SUBJECT TERMS

15. NUMBER OF PAGES 4

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (890104 Draft)
Prescribed by ANSI Std. Z39-18
298-01

89 11

It was open to the public, and 250-300 people attended. Several major issues were addressed at the conference. These included: 1) Receptor potential generation in vestibular hair cells; 2) Production of eye movements by the otolith organs; 3) Organization of the central vestibular and oculomotor systems; 4) Visual inputs to the vestibulo- cerebellum; 5) Mechanisms for adaptation of the vestibulo-ocular reflex (VOR); and 6) Study of head-eye interactions and visual-vestibular interactions in clinical disorders. Several highlights will be mentioned in each of these various areas:

1) Receptor Potential Generation: Hudspeth presented work that showed that saccular hair cells produce generator potentials only when the stereocilia and kinocilia are moved along their plane of maximum excitability. This plane splits the stereocilia and the kinocilium, and is the axis of mirror symmetry of the cell. Movements at right angles to this axis do not cause excitation. Static deflection of the hairs perpendicular to the plane of maximum sensitivity does not affect the response to hair movement in the plane of the maximum response.

2) Otolith-ocular reflexes: It is known that there is continuous reexcitation of the labyrinth during constant velocity rotation about an earth-horizontal axis. Goldberg showed that this excitation cannot come from the semicircular canals. Instead this activity probably arises in the otolith organs. Raphan showed that there is continuous nystagmus when monkeys are rotated at constant velocity in darkness about axes that are tilted more than 5-10 degrees from the vertical. He posited that the otolith organs generate compensatory eye movements during rotation about axes tilted from the vertical by coupling to the oculomotor system through a mechanism that stores activity related to slow phase eye velocity. This "velocity storage" mechanism is also accessed by the visual system and the semicircular canals, and mediates visual-vestibular interactions. The otolith- ocular reflexes described in these experiments are active at low frequencies of head movement. Tokita indicated that otolith-ocular reflexes also operate at high frequencies of linear head movement. He showed that vision complements compensatory eye movement induced by the otolith organs at lower frequencies. Thus, although semicircular canal activation is usually considered to be primarily responsible for inducing the VOR, it is now clear that the otolith organs make an important contribution to production of eye movements that compensate for head movements.

Previous work on ocular torsion produced by otolith-ocular reflexes was summarized by Diamond. She showed that static counter-rolling is not a useful clinical measure of otolith organ or labyrinthine dysfunction. Young presented evidence that the otoliths respond to gravity and to linear acceleration to produce compensatory counter-rolling. The contribution attributed to gravity disappears in weightless states. Anderson demonstrated that the region in and around the Interstitial Nucleus of Cajal is important for the generation of torsional or rolling eye movements.

3) Central vestibular and oculomotor organization: Morphological studies have identified specific types of neurons that interact to produce saccades and slow and quick phases of nystagmus. Various types of burst neurons are separately located in the brainstem (Shimazu, Berthoz). There are two major pathways that project activity from the vestibular nuclei to medial rectus motoneurons. One involves the abducens interneurons in the median longitudinal fasciculus, the other the ascending tract of Deiter s (Highstein, Baker, Markham). The technique of recording from neurons in alert animals and identifying the cells morphologically with horseradish peroxidase holds considerable promise for determining how individual elements in the VOR are coupled. Buettner-Ennever described a new anatomic technique that will permit transsynaptic identification of neurons. It should also be a powerful tool for

?

AFOSR.TR. 89-1421

tracing anatomic pathways.

4) Visual inputs to the vestibulo-cerebellum: The role that vision plays in modulating activity in the VOR has been of great interest in recent years. It has clarified why there is such extensive sensory convergence on vestibular neurons. The VOR functions to move the eyes to counter head movement so that visual targets can be seen clearly. Visual inputs that couple to the vestibular system carry visual information that would be appropriate for signaling head movement, and complement information about head movement that arises in the vestibular end organs. The sensory inputs that converge on the vestibular nuclei, including vision, audition (Schaefer, Mira) and somatosensory sensation, all contribute to maintaining activity in vestibular nuclei neurons so that it is proportional to the velocity of head and body movement. How visual information reaches the vestibular nuclei is still not clear. One possible route is through the accessory optic system and flocculus. Purkinje cells in the flocculus can modulate activity in the vestibular nuclei, and Purkinje cell activity was shown to be related to the velocity of nystagmus induced by movement of the visual surround at speeds above 60 deg/sec (Waespe). There is also activation of Purkinje cells without eye movement, solely in response to movement of the visual fields (Noda).

A number of authors focussed on the role of the accessory optic system and nucleus reticularis tegmenti pontis in serving as an input to the flocculus and in mediating visual-vestibular interactions. Karten showed direct projections to both the cerebellum and oculomotor nuclei from the accessory optic system in birds. In separate papers Precht, Maekawa and Kawasaki demonstrated that activity related to full field motion reaches the flocculus of mammals over mossy fiber inputs that arise from cells in nucleus reticularis tegmenti pontis (NRTP). Cells in NRTP also appear to be related to visual system activation in primates (Keller). Since NRTP gets projections from the accessory optic system, it could serve as a major link between the visual and vestibular systems, carrying information about movement of large fields. Such visual stimuli occur each time the head moves in a lighted surround.

5. Adaptation of the VOR: Grusser reported that if the eyes are moved voluntarily while viewing stationary periodic stimuli in flickering light, one has a strong sensation that the stationary stimuli are moving. This perception does not occur in continuous light. The sense of movement is associated with production of pursuit movements or optokinetic nystagmus (sigma OKN). This work indicates that a representation of the efferent motor signal that produced an eye movement (efference copy) is present within the central oculomotor system. Grusser suggests that it plays an important role in producing pursuit eye movements and nystagmus. Stroboscopic illumination was used to study adaptation of the VOR to reversal of vision by means of dove prisms (Melvill Jones). Nausea is a prominent and disabling symptom in the early stages of adaptation to vision reversal in continuous light. Surprisingly, motion sickness does not develop during vision reversal in flickering light. This provocative finding bears further investigation for possible use in treating motion sickness in weightlessness or in clinical disorders. A small but persistent amount of retinal slip was shown to be present during normal operation of the VOR (Steinman). It is believed necessary for maintaining visual acuity. Low frequencies of vestibular stimulation (less than 0.05 Hz) were effective in shortening the time constant of vestibular responses (Henn). Higher frequencies (greater than 0.1 Hz) did not have a similar effect. Since this type of stimulus can be given without producing motion sickness or nausea, it may be a useful way to reduce responsiveness of humans to vestibular stimuli. At least part of the ocular and sensory adaptation to motion probably involves the velocity storage mechanism mentioned above. This mechanism was shown to

participate in mediating visual-vestibular interactions in humans (Cohen; Koenig & Dichgans). Most studies on adaptation have concentrated on the gain and phase of the ocular compensation. However, when conflicting directional stimuli are given, there is adaptation for movements in various planes as well (Schultheiss & Robinson).

6. Clinical studies: A major new area of concern has emerged in vestibulo-ocular studies, namely the use of head-eye and visual-vestibular interactions for studying the integrity of the VOR and of the vestibular and oculomotor systems. The normal characteristics of head movement and head-eye interaction were described (Zangmeister, Barnes, de Jong) and disturbances of head-eye coordination during labyrinthine and central disorders were detailed (Uemura, Shimizu). Models of the VOR and of oculomotor responses were used to predict or explain findings after various lesions of the central vestibular and oculomotor system (Leigh and Zee, Baloh, Schmid). This appears to be a useful avenue for further research. Adaptation to reversal of vision was shown to be reduced in patients with cerebellar disease (Kawamura). Lesions of the central oculomotor and visual systems affect the gain of visual inputs to the VOR, (Kimura, Nakamura, Wenmo) but more work needs to be done before it is known whether fixation suppression of nystagmus represents a simple interaction of activity associated with pursuit with activity generated in the VOR.

Feedback from participants was positive and there was general agreement that the conference had fostered a productive interchange of information and ideas. Papers from this meeting will form an issue of the Annals of the New York Academy of Science. This volume should be published within the next year and copies will be sent to supplement this report.

Bernard Cohen W

Nov. 26, 1980